

CLAIMS

1. **(Currently Amended)** A computer-readable storage medium apparatus having computer-executable instructions encoded thereon for performing to support ephemeral garbage collection by setting a write-watch mechanism to watch specified memory locations, the computer-readable storage medium apparatus being accessible by a computing device, the instructions when executed, configuring the computing device such that during execution of a program, when a statement of the program for execution is obtained, the computing device is configured to determine whether the statement includes a store operator, the computing device being further configured to perform operations comprising:

in an event the statement has a store operator:

storing a value specified in the statement in a memory location specified in the statement; and

determining whether the memory location specified is within an ephemeral generation;

in an event the memory location specified is within the ephemeral generation, obtaining a next statement of the program for execution;

in an event the memory location specified is not within the ephemeral generation, setting a card associated with the memory location specified and obtaining the next statement of the program for execution;

requesting via the write-watch mechanism a list of memory locations ~~from a tracking mechanism, wherein the tracking mechanism comprises a write-watch mechanism, and the list:~~

~~identifies~~ identifying a plurality of the memory locations that have been accessed since a last ephemeral garbage collection process, each memory location corresponding to one of a plurality of cards ~~that are~~ associated with one or more objects allocated from within a memory heap, each of the plurality of cards ~~being~~ associated with a card table, wherein the card table identifies one or more of the plurality of cards with objects that have been accessed; and

~~comprises~~ comprising a bitmap ~~and, wherein~~ each bit within the bitmap corresponds to one of the plurality of cards, modification of the bitmap occurring when a corresponding bit is set at the time that the card is trimmed to disk;

creating, during the current ephemeral garbage collection process, a bundle table containing entries identifying a plurality of bundles, wherein each of the plurality of bundles identifies groupings of subsets of the plurality of cards;

marking, during the current ephemeral garbage collection process, two or more of the plurality of bundles identified in the bundle table using the list, wherein the marked bundles identify groupings of subsets of the plurality of marked cards having associated objects that have been accessed since the last ephemeral garbage collection process; and

~~for each marked bundle identified in the bundle table, determining at least one marked card in a grouping of subsets of the plurality of marked cards identified by the marked bundle;~~

~~for each determined marked card, determining at least one accessed object associated with the marked card; and~~

performing garbage collection upon ~~[[the]]~~ at least one accessed object.

2. (Canceled)

3. (Previously Presented) The computer-readable storage medium apparatus of claim 1, wherein the write-watch mechanism operates within a memory manager.

4. (Previously Presented) The computer-readable storage medium apparatus of claim 1, wherein the write-watch mechanism records a first access to one of the plurality of memory locations.

5. (Canceled)

6. (Currently Amended) The computer-readable storage medium apparatus of claim 1, wherein the write-watch mechanism maintains the list of memory locations ~~is maintained~~ in response to a request from the ephemeral garbage collection process.

7. (Previously Presented) The computer-readable storage medium apparatus of claim 1, further comprising resetting the list of memory locations.

8. (Previously Presented) The computer-readable storage medium apparatus of claim 1, wherein the subset of cards corresponds to a number of cards that are tracked using a page of memory storing the card table.

9. (Previously Presented) The computer-readable storage medium apparatus of claim 1, wherein identifying the marked bundle comprises marking a bit associated with the marked bundle table within a bundle bitmap based on the memory locations within the list.

10. (Previously Presented) The computer-readable storage medium apparatus of claim 9, wherein marking the bit comprises setting the bit.

11. (Currently Amended) The computer-readable storage medium apparatus of claim 1, wherein determining the at least one marked card comprises scanning a card bitmap having a bit for each of the plurality of cards, the bit for each marked card being different than another bit of the card bitmap associated with one of the cards that was not accessed.

12. (Currently Amended) A method for executing statements within a program to support ephemeral garbage collection by setting a write-watch mechanism to watch specified memory locations such that during execution of a program, when a statement of the program for execution including a store operator is obtained, a computing device is configured to perform the method comprising:

specifying a range of card table memory to watch during program execution by calling a write-watch mechanism that:

performs tracking of ~~[[the]]~~ access to the card table memory; and

maintains a write-watch list that identifies cards ~~accessed~~ written within the card table memory since a garbage collection process was last performed, ~~[[,]]~~ each card being associated with and updated upon access to one or more objects allocated within a

memory heap, the memory heap being divided into ~~[[the]]~~ a plurality of cards with each card being grouped into one of a plurality of bundles, wherein one of the plurality of bundles corresponds to a subset of that plurality of cards that are tracked using a page of card table memory;

in an event the statement obtained has a store operator:

storing a value within the memory heap at a memory location specified by

~~a storing the statement~~ obtained[[,]]; and

determining whether the memory location specified is within an ephemeral generation;

in an event the memory location specified is within the ephemeral generation, obtaining a next statement of the program for execution;

in an event the memory location specified is not within the ephemeral generation, marking one of the plurality of cards within the card table memory corresponding to the memory location and obtaining a next statement of the program for execution[[;]]

~~tracking access to the card table memory by the write watch mechanism;~~

~~creating, only during an ephemeral garbage collection process, one or more bundle tables containing entries identifying groupings of the cards in the plurality of bundles, for each stored statement within the program, the ephemeral garbage collection process occurring exclusive of the program execution process;~~

~~updating, during the ephemeral garbage collection process, at least one bundle table by marking the entries in the bundle table based on information obtained from the write watch list,~~

~~wherein the updated marked bundle table identifies groupings the plurality of marked cards having associated objects that have been accessed since a last garbage collection process;~~

~~for each marked bundle table, determining during the ephemeral garbage collection process at least one marked card in a grouping of the plurality of marked cards identified by the marked bundle table;~~

~~for each marked card, determining during the ephemeral garbage collection process, at least one accessed object associated with the marked card; and~~

~~performing garbage collection during the ephemeral garbage collection process upon the at least one accessed object.~~

13. (Canceled)

14. (Currently Amended) The method of claim 12, wherein the tracking includes the write-watch mechanism that resides within a memory manager ~~and sets~~ setting bits in the card table memory upon access to at least one of the plurality of cards.

15. and 16. (Canceled)

17. (Currently Amended) The method of claim 12, ~~wherein~~ further comprising an ephemeral garbage collection process that requests the write-watch list when performing [[a]] garbage collection ~~eyele~~.

18. (Currently Amended) The method of claim 12, wherein ~~[[the]]~~ an ephemeral garbage collection process determines a marked bundle based on the write-watch list.

19. (Currently Amended) A memory management system configured to set a write-watch mechanism to watch specified memory locations during execution of a program, obtain a statement of the program for execution, determine whether the statement obtained includes a store operator, the system comprising:

a processor; and

a memory into which a plurality of instructions are loaded and into which a plurality of objects are dynamically allocated, the memory having a heap into which the objects are allocated, the heap being divided into a plurality of cards which are grouped into a plurality of bundles, each card being associated with ~~a group~~ one or more of the plurality of objects, wherein upon execution of the plurality of instructions by the processor, the system being configured to~~[[:]],~~ based at least on whether the store operator is included in the statement for execution obtained, the system being further configured to perform an operation such that:

in an event the statement obtained does not have a store operator, executing the statement; and

in an event the statement obtained has a store operator:

storing a value specified in the statement obtained in a memory location specified in the statement obtained;

determining whether the memory location specified is within an ephemeral generation;

in an event the memory location specified is within the ephemeral generation, obtaining a next statement of the program for execution; and

in an event the memory location specified is not within the ephemeral generation, setting a card associated with the memory location specified and obtaining the next statement of the program for execution

~~request a list from a tracking mechanism, the list identifying memory locations that have been written into since a last garbage collection cycle, each memory location corresponding to one of the plurality of cards associated with a card table, wherein the card table identifies one or more cards that have been accessed, the card table and cards being marked to identify the one or more of the plurality of cards with the group of objects that have been accessed, during a first program execution process exclusive of an ephemeral garbage collection process;~~

~~creating, during the ephemeral garbage collection process, one or more bundle tables wherein each bundle table identifies groupings of the plurality of cards in the plurality of bundles;~~

~~updating, during the ephemeral garbage collection process, at least one bundle table by marking bundles within the bundle table based on the list, wherein the marked bundles corresponds to marked cards having associated objects that have been accessed since the last garbage collection cycle;~~

~~determine, during the ephemeral garbage collection process, for each marked bundle within the bundle table, at least one marked card within the marked bundle, the at least one marked card indicating that objects associated with the marked card have been accessed;~~

~~determine, during the ephemeral garbage collection process, for each marked card, the one or more objects that have been accessed; and~~

~~perform, during the ephemeral garbage collection process, garbage collection upon the one or more accessed objects.~~

20. (Canceled)

21. (Currently Amended) The system of claim ~~[[20]]~~ 19, wherein the write-watch mechanism resides within a memory manager and sets bits in ~~[[the]]~~ a card table upon access to at least one of the plurality of cards.

22. (Canceled)

23. (Currently Amended) The system of claim ~~[[19]]~~ 31, wherein the marked bundle ~~being is~~ identified by a marked bit associated with the marked bundle within a bundle bitmap based on the list.

24. (Currently Amended) The system of claim ~~[[19]]~~ 31, further being configured to set a bit in the card table to identify one or more cards that have been accessed at the time a card that has been accessed is trimmed to disk.

25. (Previously Presented) The method of claim 12, wherein the write-watch mechanism sets bits in the card table memory upon access to at least one of the plurality of cards at the time that the card is trimmed to disk.

26. (Currently Amended) The method of claim 12, further comprising:

determining whether ~~the call to~~ calling the write-watch mechanism resets a write-watch state by inquiring which cards have changed without being considered as having asked and thereby resetting the state, and

in an event the state is to be reset, placing a separate reset call to reset the range of card table memory without reporting whether the cards in the range have been marked.

27. (Currently Amended) The system of claim 19, further being configured to:

determine whether ~~[[the]]~~ a request resets a write-watch state by inquiring which memory locations have changed without being considered as having asked and thereby resetting the state, and

in an event the state is to be reset, the system being configured to place ~~places~~ a separate reset request to reset a range of memory locations without reporting whether the memory locations in the range have been marked.

28. (New) The computer-readable storage medium apparatus of claim 1, the operations further comprising using, by a current ephemeral garbage collection process, information from the write-watch mechanism to determine which bundles in older generations have objects for collection.

29. (New) The computer-readable storage medium apparatus of claim 1, the operations further comprising:

for each marked bundle identified in the bundle table, determining at least one marked card in a grouping of subsets of the plurality of marked cards identified by the marked bundle; and

for each determined marked card, determining at least one accessed object associated with the marked card.

30. (New) The method of claim 12, further comprising:

tracking access to the card table memory by the write-watch mechanism;

creating, during an ephemeral garbage collection process, one or more bundle tables containing entries identifying groupings of the cards in the plurality of bundles, for each stored statement within the program, the ephemeral garbage collection process occurring after the program execution process;

updating, during the ephemeral garbage collection process, at least one bundle table by marking the entries in the bundle table based on information obtained from the write-watch list, wherein the updated marked bundle table identifies groupings the plurality of marked cards having associated objects that have been accessed since a last garbage collection process;

for each marked bundle table, determining during the ephemeral garbage collection process at least one marked card in a grouping of the plurality of marked cards identified by the marked bundle table;

for each marked card, determining during the ephemeral garbage collection process, at least one accessed object associated with the marked card; and

performing garbage collection during the ephemeral garbage collection process upon the at least one accessed object.

31. (New) The system of claim 19, further being configured to:

request a list from the write-watch mechanism, the list identifying memory locations that have been written into since a last garbage collection process, each memory location corresponding to one of the plurality of cards associated with a card table, wherein the card table identifies one or more cards that have been accessed, the card table and cards being marked to identify the one or more of the plurality of cards with the one or more objects that have been accessed, during execution of the program exclusive of an ephemeral garbage collection process;

create, during a current ephemeral garbage collection process, one or more bundle tables wherein each bundle table identifies groupings of the plurality of cards in the plurality of bundles;

update, during the current ephemeral garbage collection process, at least one bundle table by marking bundles within the bundle table based on the list, wherein the marked bundles corresponds to marked cards having associated objects that have been accessed since a last ephemeral garbage collection process;

determine, during the current ephemeral garbage collection process, for each marked bundle within the bundle table, at least one marked card within the marked bundle, the at least one marked card indicating that one or more objects associated with the marked card have been accessed;

determine, during the current ephemeral garbage collection process, for each marked card, the one or more objects that have been accessed; and

perform, during the current ephemeral garbage collection process, garbage collection upon the one or more accessed objects.